1015 Issued August 8, 1907.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 303

Corn-Harvesting Machinery.

BY

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PREPARED UNDER THE SUPERVISION OF THE OFFICE OF EXPERIMENT STATIONS,
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WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1907.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., June 19, 1907.

SIR: The demand for the report on corn-harvesting machinery prepared by C. J. Zintheo and published as Bulletin 173 of this Office has been much greater than the somewhat limited edition of that bulletin would supply. For this reason it has been deemed advisable to condense the original report within the limits of a Farmers' Bulletin and so provide for a wider distribution of the more important information it contains. Such a condensed summary is transmitted herewith and recommended for publication as a Farmers' Bulletin of the Department.

Respectfully,

A. C. TRUE,
Director.

Hon. JAMES WILSON,
Secretary of Agriculture.

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CORN-HARVESTING MACHINERY.

INTRODUCTION.

Machinery for the care of the corn crop has been much more difficult to develop than any other line of farm implements. Although there has been considerable progress in methods of harvesting corn, the larger part of the crop is still husked by hand from the standing plant, only the ears being gathered, while the leaves and stalks are almost a total loss. This results in an enormous waste of valuable feed, for it has been demonstrated that when properly harvested corn fodder is as nutritious as good hay, and that the farmer who would receive the full value of his corn crop should secure this fodder with as much care as he gives his hay.

After the success of mowing and reaping machines, inventors tried to developed a corn harvester along the lines followed in the construction of those machines. Their success is not as yet complete, but the labor-saving devices so far perfected have largely changed conditions. The corn may now be cut, husked, and shredded with less labor than the cutting alone formerly required. At the same time all of the fodder is made available for feeding purposes.

CORN CUTTING WITH KNIVES.

A common method of harvesting corn is to cut the stalk close to the ground at a time when no damage is done to the ripening grain and while considerable of the saccharine juices still remain in the stalk.

The implement first used for corn cutting was the hoe, but as this was rather heavy and awkward the more progressive farmers substituted the corn knife. For a long time scythe blades were largely used in making corn knives, but these have now given way to all sizes and shapes of factory-made knives. The corn hook (fig. 1), which is now extensively used, is generally considered more convenient than the corn knife.

When the corn is cut it is customary to set it up in shocks to cure. Shocks vary greatly in size, ranging from 6 hills square (36 hills to the shock) to 16 hills square (256 hills); a very common size is 12 hills square (144 hills). Shocks of the smaller sizes are common in the North Atlantic States, where, according to the Connecticut Station, it is more difficult to preserve flint-corn stover; while 10 hills square

and 12 hills square are common sizes in the North Central States. The common or four-saddle shock method consists in tying the tops of four hills together as they stand and then cutting and shocking the rest of the hills around these. Another method of making the shock is to use a wooden horse as a temporary support. In either case the shock is built around the support with great care to prevent it from being blown over by heavy winds or damaged by rain. In some cases the corn is tied into small bundles, which are set together to form the shock; more commonly the stalks are gathered as cut and set up an armful at a time. Where the wooden horse is used the shock is built about the horse by leaning the first bundles or armfuls against a pair of projecting arms formed by inserting a pole through a hole bored at right angles to the horse (fig. 2). When the shock has been set up the pole is withdrawn and the horse removed. When completed the shock is tied tightly near the top. A rope with a hook at one end is sometimes used to draw the tops together before tying. Sometimes shocks are not tied.

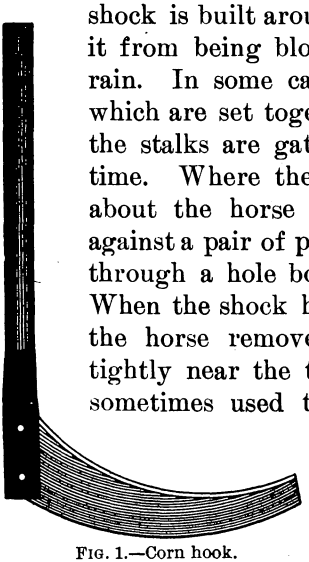

FIG. 1.—Corn hook.

After the fodder has become cured, which usually takes about a month, the shocks are generally husked by hand in the field, and the stover is commonly tied into bundles and reshocked. Frequently the stover from two or more shocks of corn is put up in a single shock. For convenience in husking a movable table is sometimes used, on which the stalks are laid while being husked. The ears are thrown in piles on the ground near the shocks and afterwards hauled to the crib. The stover is sometimes hauled to the barn and stored, but often it is left standing in shocks in the field till needed for feeding during the winter. It is important to choose suitable weather conditions for husking, since if the plants are too dry the stalks will break and blades will fall off and be lost. On the other hand, extremely wet weather makes the ground too soft for hauling in the corn.

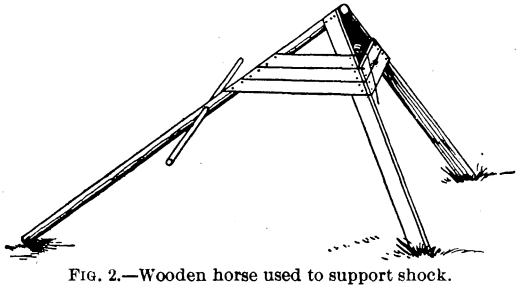

FIG. 2.—Wooden horse used to support shock.

The cost of these methods of caring for the corn crop varies with the locality and the year. Taking the average of the replies to 200 inquiries, it appears that one man is able to cut and shock by hand about 34 shocks 12 hills square, or nearly 1½ acres of corn per day. The average cost per shock for cutting by hand is reported to be 6.5 cents, or $1.50 per acre.

MACHINES FOR HARVESTING CORN.

SLED HARVESTERS AND SIMILAR DEVICES.

As early as the year 1820 attempts were made to construct a mechanical corn harvester. From that year until 1892 all attempts to perfect such a machine were unsuccessful. The machines invented were patterned after the mower and the reaper, but owing to the size of the corn plant these machines either would not cut at all or were soon broken under the heavy strain. Some of the machines, however, had commendable mechanical features, which were embodied in machines invented later.

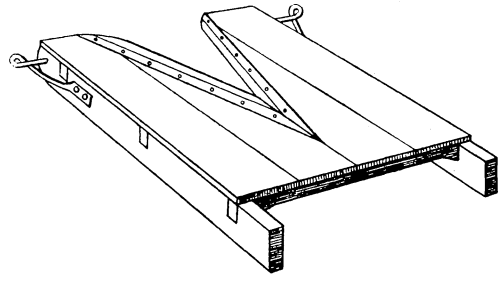

FIG. 3.—One-row sled harvester.

Homemade sled harvesters.—Many homemade harvesting devices of the sled pattern have been made from time to time, some of which are illustrated in figures 3, 4, and 5. The first harvester of this class was patented by J. C. Peterson, of West Mansfield, Ohio, who put one in the field in 1886. Others followed and added improvements until eight or ten harvesters of this kind were in the field.

With most of the sled harvesters the driver rode on the platform, and it was necessary for him to gather the stalks in his arms in advance of the cutting edge, so as to prevent them from falling in various directions. This method of harvesting was very exhausting. The harvester shown in figure 5 was an improvement, in that the guiding arm collected the stalks on the platform, and it was only necessary for the driver to pick the stalks from the sled at intervals and throw them on the ground.

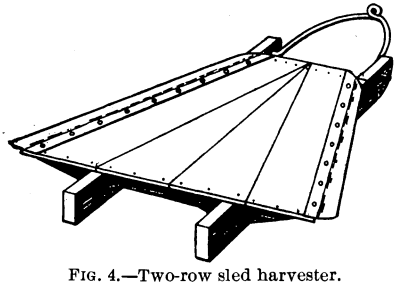

FIG. 4.—Two-row sled harvester.

A sled harvester mounted on wheels.—As an improvement, in order to reduce the draft, the sled was mounted on wheels (fig. 6). This machine cuts two rows at a time, and two men sit on the platform, one facing each row, to guide the corn against the cutting edge with one hand and with the other hand and arm to collect the cut corn on the tilting side part or wing of the platform, drawing it back against the leg, where it is assembled until enough has been collected to form a shock.

More complicated machines.—To reduce the labor involved in cutting corn with the machines described, another style of corn harvester was

invented, two forms of which are shown in figures 7 and 8. This machine consists of two driving wheels, between which is mounted the frame for the driving mechanism and platform. It is drawn by one horse, which walks between the two rows that are cut at the same time.

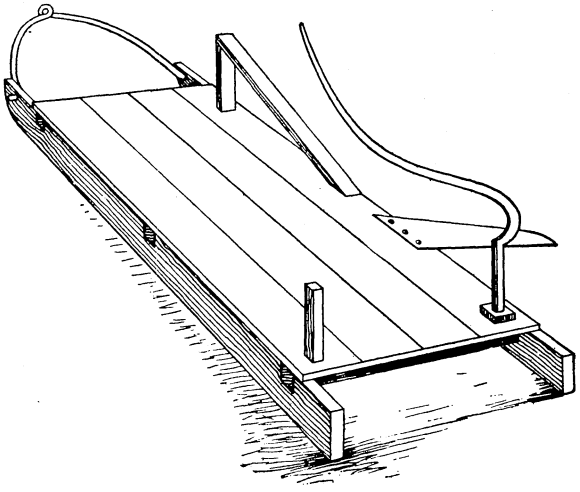

FIG. 5.—Improved one-row harvester.

The dividers pick up the lodged corn, except such as lies in the row of corn away from the machine, and guide it to the cutting apparatus, which consists of two stationary side blades, above which is a movable sickle, which cuts the corn and deposits it horizontally on a platform that is elevated about 6 inches above the cutting apparatus. On the inner side is a guide chain, which assists in directing the stalks of corn to the knife and the platform. The rear part of the machine is provided with a small wheel, above which is a tilting lever, by means of which the dividers in front can be raised or lowered to gather up

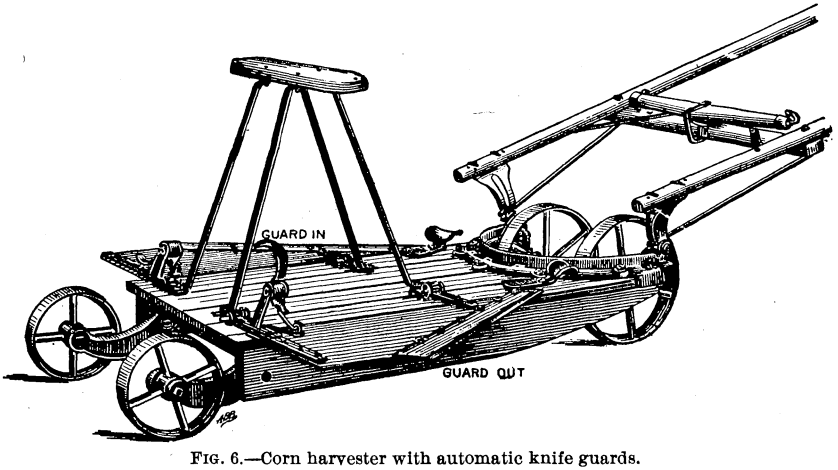

FIG. 6.—Corn harvester with automatic knife guards.

the lodged corn until it comes in contact with the endless chain, which carries it backward until it is cut and deposited on the platform. The machine shown in figure 7 has low wheels and stationary cut, while

the one shown in figure 8 can, by means of side levers, be adjusted to cut the corn from 2 to 15 inches from the ground.

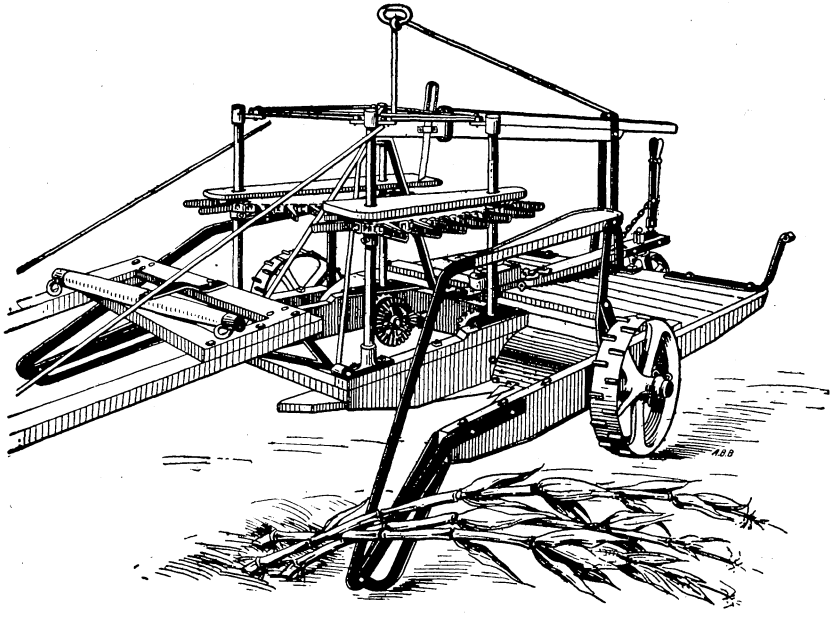

FIG. 7.—Two-row corn harvester with stationary lift.

Machines of this type gather and cut the corn and drop it on the platform. When there is enough to start a shock, the horse is stopped and the corn is set up.

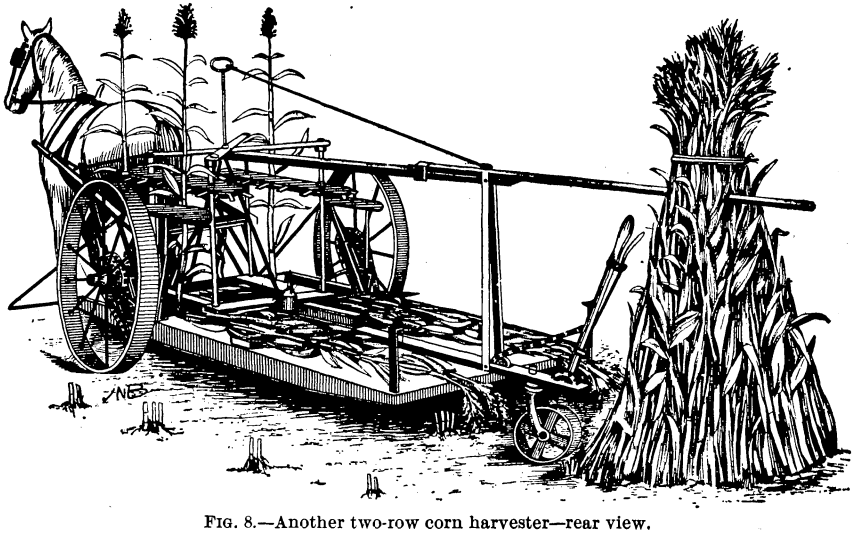

FIG. 8.—Another two-row corn harvester—rear view.

Cost and efficiency.

These different forms of corn harvesters vary in price from $5 to $55, and, while their low cost is a great advantage, their degree of efficiency is not very high. The cheap sled harvesters can be used only when the corn stands straight, and the horse must walk rather fast in order that the work may be perfectly done. It is also hard work for the men to gather and shock the corn. The work of harvesting corn is such that only the best construction can withstand the strain for any great while, and hence these machines are being used less than formerly.

From 90 replies to a letter of inquiry regarding the cost of harvesting with these machines, sent to a large number of farmers in different parts of the country, it was learned that the minimum in area of corn cut per day was 2 acres and the maximum 10 acres. The average from all the replies was 4.67 acres of corn cut per day by two men and one horse, using the sled harvester. As to cost per acre for harvesting corn the minimum price reported was 55 cents per acre and the maximum $2. Taking the average of all the replies received, the cost of harvesting corn with a sled harvester was $1.18 per acre. This is estimated on a basis of 18 cents per acre, or 84 cents per day, for the use of the machine and repairs; 4 cents per acre, or 19 cents per day, for twine; 58.5 cents per acre, or $2.75 per day, for one horse and a man who does part of the shocking, and 37.5 cents per acre, or $1.75 per day, for the other shocker. Comparing this cost per acre with that of hand cutting (p. 6), it will be noted that there is a saving of 32 cents per acre in favor of the machines. It will also be noticed that two men and a horse with a sled harvester can cut and shock 4.67 acres per day, as against 1.47 acres per day for one man with a knife, which gives a credit of 1.73 acres per day for the work of the horse, or a considerable saving in favor of the machine.

CORN BINDERS.

Historical.

The credit of inventing corn-harvesting machinery belongs to Edmund W. Quincy, of Illinois, as he obtained the first patent on a corn-harvesting machine in October, 1850. This machine, like many others, was intended to pass over the row and pick the ears from the stalks. Another form of corn harvester (fig. 9), invented in the eighties, cut the cornstalks and elevated them into a wagon. The elevator could be removed and a binder attachment put on by which the corn was bound into bundles. One of the earliest forms of corn harvester and binder was constructed as a modified form of the grain binder. This machine also was so constructed that for the binder

attachment there might be substituted a device to elevate the corn into a wagon.

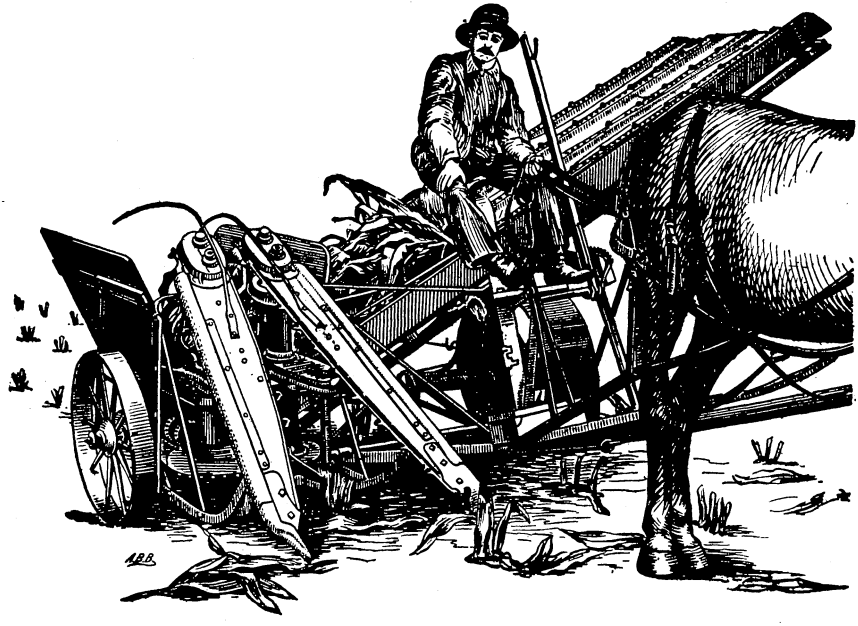

FIG. 9.—An early corn harvester.

A machine embodying principles which were destined to prevail in corn harvesters was invented by A. S. Peck, of Geneva, Ill., and was

FIG. 10.—Vertical corn harvester in the field.

patented January 5, 1892 (fig. 10). It consisted of a corn harvester with the two dividers passing one on each side of a row of corn, which

was cut and carried back in a vertical position to the binder attachment by means of chains and gathering arms. A standard twine binder was used, set in a vertical position so as to receive the stalks and keep them in this position until the bundle was discharged. The horses were hitched behind the machine as they are on the header.

The Peck patent received very little attention at first. It showed very few elements that were new, as the vertical principle of cutting grain had been tried and failed to give satisfaction. It was rather a rearrangement of well-known principles used in harvesting machinery than a new departure. However, after two years' use by the inventor and a few other persons, its merit was recognized by one of the prominent harvester manufacturers.

From the date of the Peck patent until 1895 many machines were made which would work well in the hands of the inventors, but few were so perfected as to be entirely successful in general use.

Since 1895 the self-binding corn harvester has had a considerable sale. In practically all of the corn binders now built the features of the Peck type predominate. Even the most divergent forms still retain the general organization of parts used in the Peck machine. Among the practical and successful corn binders in the market the widest divergence from the Peck type is probably to be found in the machine invented by John A. Stone, of Chicago. In this machine the binder is in an almost horizontal position, instead of vertical. When the corn is cut the stalks move a little rearward in an upright position, and then they are tripped so that the tops fall rearward onto an inclined deck, being guided in their fall toward the binder by curved guide arms. The butts are pushed out of the way of the incoming cornstalks, and are evened for a bundle by means of a butt adjuster.

A type of corn binder, which comes about halfway between those already described, was invented by Tarrall and Maul, of Batavia, N. Y. It is designed to occupy an inclined position over the deck for the purpose of binding the stalks in a semiprostrate position.

Construction.

There are, therefore, three different forms of corn binder, namely, the vertical, the horizontal, and the inclined, the latter being rather a blending of the two preceding types. These machines differ only in the relative position of their elements, being composed of the same essential parts. Binders consist essentially of the dividers, of which previous mention has been made, and of cutting and binding devices. (See figs. 11, 12 and 13.) A bundle carrier is usually also attached, but this is not essential to the smooth operation of the machine.

Dividers.—The dividers consist of two diverging jaws opening at the front of the machine. The jaws begin in two points at the front, but gradually widen vertically to where they join the frame of the machine, when they have a width, or rather a height, of 4 feet or more. By an arrangement of levers the points may be raised or lowered. Attached to each jaw are two or three traveling chains, whose purpose it is to bring the stalks to a vertical position and carry them back to the binding deck. The chains are placed one above the other (fig. 11). The lower one is known as the short-corn chain, the middle one is the conveyor chain, and the upper one is the tall-corn chain. The middle chain passes around a sprocket wheel close to the point of the jaws, and extends back almost to the binding deck. The upper chain begins farther back and extends some distance over the binding

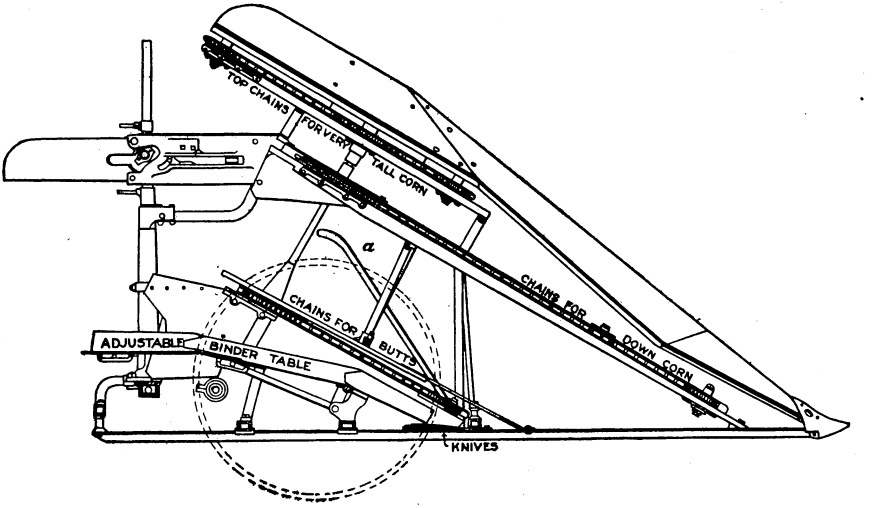

FIG. 11.—Skeleton frame of corn binder, showing chains.

deck. This chain is meant to carry the tops of tall corn. The lower chain is of about the same length as the upper one, begins nearer the point of the jaw, and does not extend so far back. These chains are supplied with fingers, which take hold of the stalks and lift them to a vertical position as the machine advances. The jaws have such a position relative to each other as will bring the fingers of the opposite chains almost in touch with each other at or near the cutting blades. The chains receive their motion from the main driving mechanism, and are driven at such speed as will bring the stalks to the proper position for cutting without shaking them too severely.

Cutters.—The cutting arrangement consists of a serrated knife which passes to and fro across two stationary blades, one of these being attached to each jaw. This serrated knife is driven by a pitman

attached to a weighted wheel called a "fly wheel." The added weight gives enough stored energy to sever the toughest stalks without shock to the small gear wheels (fig. 12).

Attached to the rear of the dividers and extending around the binding deck are several guide springs (fig. 10) which keep the tall corn from bending over and becoming entangled in the binding gear.

Binding apparatus.—Just behind the knife and thence extending back to the bundle carrier is the butt shoe, or butt carrier (fig. 11). This device carries the weight of the stalks after they are cut. It is fastened to the frame just behind the knife, but through the rest of its length it is adjustable vertically, so that the binding twine may be placed at the proper place on both tall and short corn.

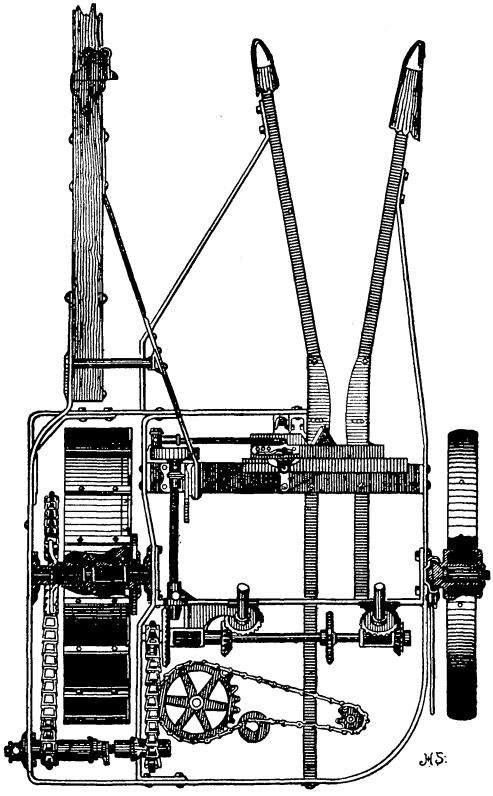

FIG. 12.—Frame of corn binder, showing mechanism for driving cutter knife, gear shaft for driving chains and binding device, and roller bearings.

As the stalks are cut they are carried back by the conveyor chain, with their butts resting in the butt carrier until they reach the binding deck, where they are pushed backward by the packers, which have such a motion as will carry them perpendicularly through the binding deck and parallel to it while conveying the stalks to the knotter. Their motion is more rapid than that of the chains, but they have the advantage of yielding slightly while a bundle is being tied. This is important, as many ears would otherwise be knocked off by jamming the stalks behind the needle.

The needle and the knotter form the binding attachments. They are in nearly all cases of the same pattern as are those of the grain binders of the same makes, but are made heavier to meet the requirements of the work.

The packers on these machines (fig. 13) must have such a motion as to travel toward the back of the machine as long as they project above the binding deck, their travel through the deck being fast and

of short duration. There is one machine on the market which does not use packers at all, but has instead several chains with collapsing fingers. While the bundle is being formed, these fingers assume a position perpendicular to their chains, being held so by the guides over which they travel. As soon, however, as the needle moves, these guides no longer bear against the fingers, which collapse when pressure is brought to bear against them. This prevents their jamming the incoming corn against the rib of the needle while a bundle is being tied and avoids the breaking off of ears that would often occur otherwise.

When the bundle has been bound the two or three discharge arms on the binding shaft have reached the back side of the bundle, and by the continuous motion of the shaft the arms force the bundle off the deck and discharge it, after which the compressor hook returns automatically to its place and the binding shaft stops until another bundle is formed, when the operation is repeated. Figure 13 shows the binding mechanism and the general arrangement of the several parts referred to.

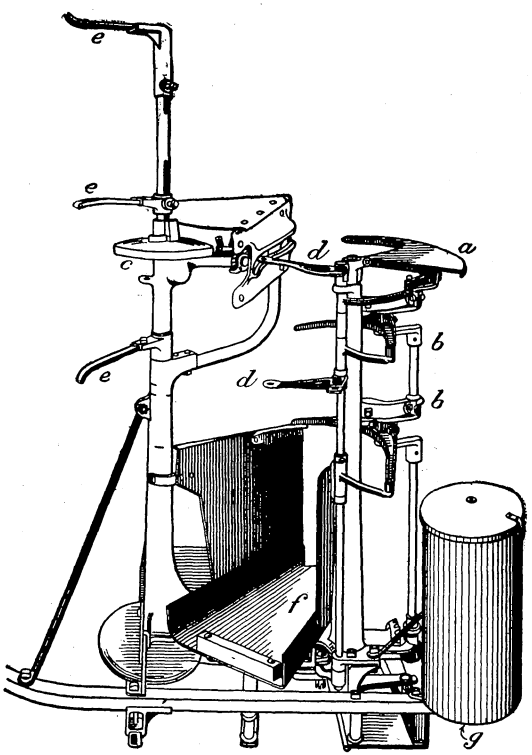

FIG. 13.—Binder attachment: *a*, Needle; *bb*, packers; *c*, knotter cam; *dd*, compressor hook; *eee*, discharge arms; *f*, butt table or butt shoe; *g*, twine cam.

Special features.—The parts that are adjustable by lever are the butt shoe, the dividers, and in some machines the binding deck and knotter and needle. The whole frame of the machine may be raised or lowered by means of the two worm-and-pinion arrangements, one on the grain wheel and one attached to the main drive wheel.

In the vertical machine the binding mechanism has a vertical position; in the horizontal machine it sits horizontally on the frame, and in the inclined machine it is inclined.

In the horizontal machine it is necessary to extend a conveyor chain farther back than in either of the other types, so as to bring the tops of the stalks into a horizontal position. In this type, too, the bundle carrier extends in a direction parallel to the length of the

machine. This arrangement is very apt to give trouble from the butts of stalks becoming lodged in stubble or soft earth and spreading the bundles in disorder upon the ground. This might be avoided more or less by giving the bundle a sharp toss, thus freeing the carrier before any part of it touches the ground. The fingers of the carrier are sometimes made free to move backward and forward so as to prevent the drag above referred to. On the vertical and inclined machines there is less danger of trouble from this source, as the bundle carriers extend across the path of the machine. The smooth operation of the carriers depends greatly on the skill of the operator. Too many bundles crowd the carrier and prevent the binding attachment from properly freeing itself, causing the leaves of the stalks in one bundle to become wrapped about the stalks in another.

The tall-corn chains may be removed where the corn is short or of medium height, and in clean fields of tall corn the short-corn chains are unnecessary. In short corn the lower chain has sometimes proven inadequate alone to properly convey the stalks to the binding deck. By the addition of a small iron rod or spring (shown at *a*, fig. 11, p. 13) on each of the dividers the choking of the binding gear is prevented and a more nearly perfect bundle is made. A short iron bar has also been added on many machines to serve the same purpose. This is usually placed in a horizontal position between the lower and middle chains. The dividers are adjustable vertically, allowing them to pick up corn that is lying flat upon the ground, the lever being in reach of the driver.

To protect the mechanism from the stalks of the uncut rows a guide rod of hickory or other tough wood is usually attached to the dividers and extended as far back as is necessary. It may be raised or lowered independently of the dividers, however, so as to give protection against either tall or short corn. This bar is shown at the left in figure 14 and the tilting lever on the right.

Badly tangled fields make the progress of one of these machines slow, but it is remarkable with what precision the chain conveyors right the stalks. The adjustment is accomplished by tilting the machine forward or backward by the tilting lever, according to whether it is desired to lower or raise the points of the dividers. As the weight is almost evenly distributed on either side of the main shaft it takes but a very little power to bring the dividers into the desired position.

There are two types of these dividers—the vertical (see fig. 10, p. 11) and the inclined (fig. 14). For the vertical it is claimed that little jostling is given the corn, decreasing the danger of knocking off ears, while advocates of the inclined pattern claim to accomplish the same result by allowing the stalks to recline against the inner jaw and be carried backward between the fingers of the conveyor chain on that side.

Owing to the great variation in height of corn, even in the same field, the binding attachments are given great range of operation. In some machines they are placed as high as 32 inches. On machines of this range it is customary to have two needles, each covering half of the variation in the position of the knotter. With such a large range as this it is possible to tie the bundles sufficiently low without raising the stalks any great distance, thereby reducing the work required of the machine. In most machines the motion is taken from the inside; in some, however, it is taken from the outside hub of the main driver. (See fig. 12, p. 14.) The arrangements for reducing friction and excluding dust from the bearings receive careful atten-

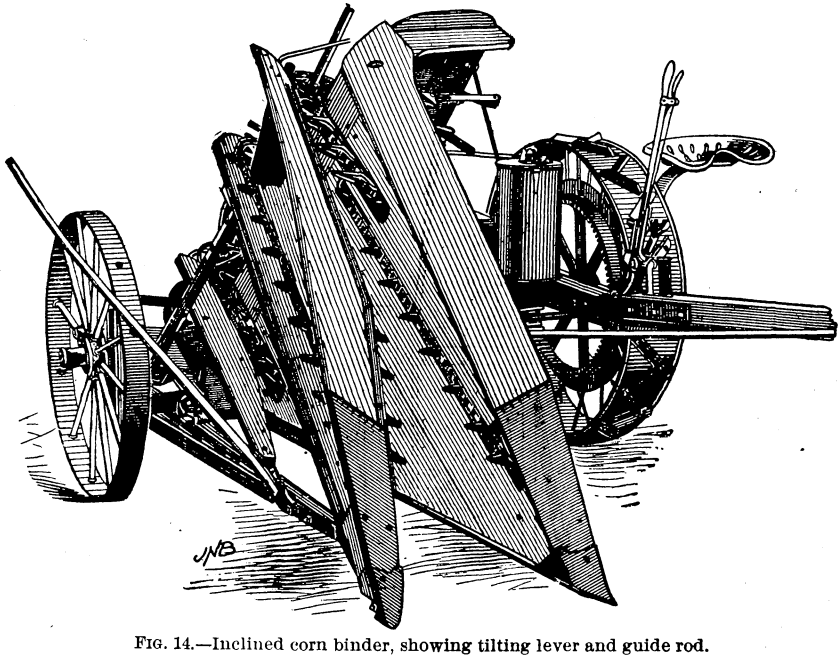

FIG. 14.—Inclined corn binder, showing tilting lever and guide rod.

tion, as may be noted from the numerous roller bearings and brass bearing boxes. Gears are also protected wherever possible, to prevent wear from dirt and grit. Where gears are not properly protected and oiled, there is apt to be a great loss of power, to say nothing of the wear. When they receive careful attention, however, the power required to move them is reduced considerably below that required for chain and sprocket. The driving power is increased by means of lugs cast or riveted on the rim of the main drive (fig. 14). They are made of various shapes, the object of all being to sink into the earth in such a way as to prevent slipping. Tubing, angle iron, and bar iron are used almost exclusively in the construction of the frames. These give strength and lightness, features which are most essential

to a perfect machine. The attendant, from his seat on the machine, has perfect control over all parts. The levers at his side operate all adjustments, and the position of the bundle carrier is controlled by a foot-lever attachment.

These machines weigh, complete, from 1,400 to 1,800 pounds. Generally speaking, those weighing in the neighborhood of 1,500 pounds have been most successful, this weight seeming to give the proper relation between driving power and durability.

The corn binder is used to greatest advantage in fields where the corn is check-rowed, as it is possible to cut around a block, keeping the machine constantly in operation.

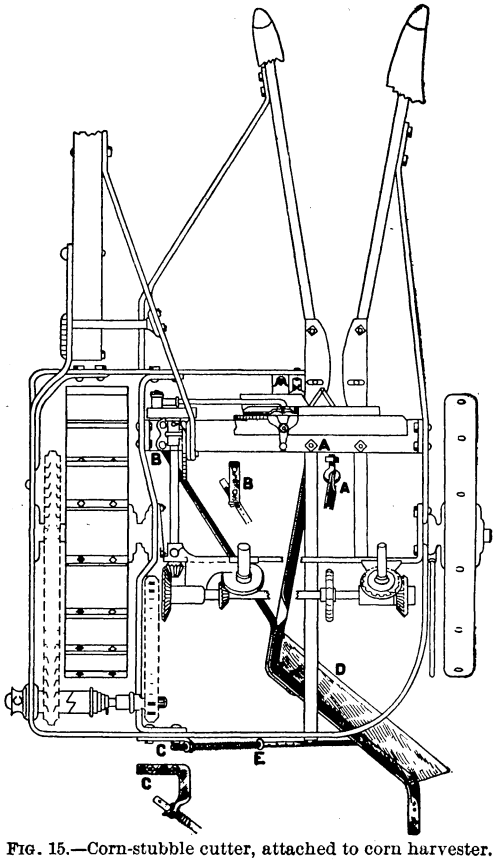

FIG. 15.—Corn-stubble cutter, attached to corn harvester.

The corn-stubble cutter.—When the corn is cut high with a corn binder, the farmer experiences considerable difficulty in getting rid of the corn stubble. In order to obtain a clear field and to have the cornstalks cut close to the ground, an attachment has been invented as shown in figure 15. This knife is attached to the under side of the machine and floats on the ground, cutting the stalks even with the surface. The cutter (D) has a drawing, slanting cut against spring resistance (E), making a clean cut. When this attachment is used, the binder is usually set to cut higher. The stubs, if cut when sappy, will decay quickly, and are left on the ground to form humus in the soil; and the ground may be prepared for the next crop with greater thoroughness.

Draft.

The average draft of corn binders is about the same as that of a 6-foot grain binder. The corn binder should therefore be propelled by three horses, the same as are required for grain binders. Draft tests of the corn binder, with a stubble-cutter attachment, shows the following results:

Draft of corn binder with and without stubble cutter.

	Pounds.
Draft with stubble cutter	437
Draft without stubble cutter	420
Draft of stubble cutter	17

Cost and efficiency.

The average results, taken from the several hundred replies received to a letter of inquiry, indicate that for all conditions of corn the average number of acres of corn cut per day with a corn binder using three horses was 7.73 acres. The average number of acres which one man can shock per day after a corn binder was 3.31 acres. The average number of pounds of twine used per acre of corn cut was 2.44. The average life in years of corn binders was 8.17, and in acres of corn cut 668.77. The average first cost of corn binders was $125. The average cost of machine per acre cut, which includes price of machine, repairs, and interest on the investment, was 29 cents per acre; the cost of driver and team per acre cut 46 cents, or $3.55 per day; the cost of twine 30.5 cents per acre. The cost of shocking the corn after a corn binder is 44.8 cents per acre. This gives the total cost per acre of harvesting corn with a corn binder, $1.50.

The cost of cutting corn with the corn binder is therefore the same as the cost for cutting corn by hand, and 32 cents per acre higher than the cost of cutting with a sled harvester. This extra cost of cutting with the corn binder over the cost of cutting with the sled harvester may be attributed to the cost of the twine and the interest on the investment in the higher first cost of the machine.

One disadvantage in the use of the corn binder is that it knocks off more or less ears of corn, which either have to be picked up by hand, at a cost of about 10 cents per acre, or left to waste or to be found by the cattle after the field is cleared.

Farmers sometimes hire their corn cut at a rate of 75 cents to $1 per acre for the use of the machine, the driver, and the team. The average cost of cutting given above was 29 cents per acre for the use of the machine and 46 cents per acre for the driver and team, or 75 cents per acre. The charge for hiring the work done is only slightly above this.

THE CORN SHOCKER.

Although the earlier efforts were centered upon the construction of the corn shocker, the perfection of this machine was delayed until after the introduction of the corn binder. In the first machines the inventor attempted to engage the stalks by extending rods or springs in advance of the cutting knives, but this did not prove as successful as did the dividers of the corn binder. With these the corn could readily be brought to an erect position and thus made into a perfect shock.

Description.

The present corn shocker was invented in 1888, and a machine was constructed that year by A. N. Hadley. It was built with a frame mounted on two wheels, the same as the corn binder, and consisted of a corn-gathering device—revolving reels on vertical standards—the upper bearings of which were arranged for adjustment laterally and fore and aft. It had as a cutting device two circular rotating cutters, operating against each other and cutting the corn as the machine advanced toward it. Behind the cutting device was a circular rotating table, 5 feet in diameter, upon which the corn was collected vertically to form a shock. On this table were several radial ribs, which aided in revolving the standing corn. In the center of this table was a rotating shock-forming standard, having radial arms around which the corn was collected. A revolving crane was mounted on the frame and a rope and pulley attached above the shock, by which it could be lifted from the platform and deposited on the ground.

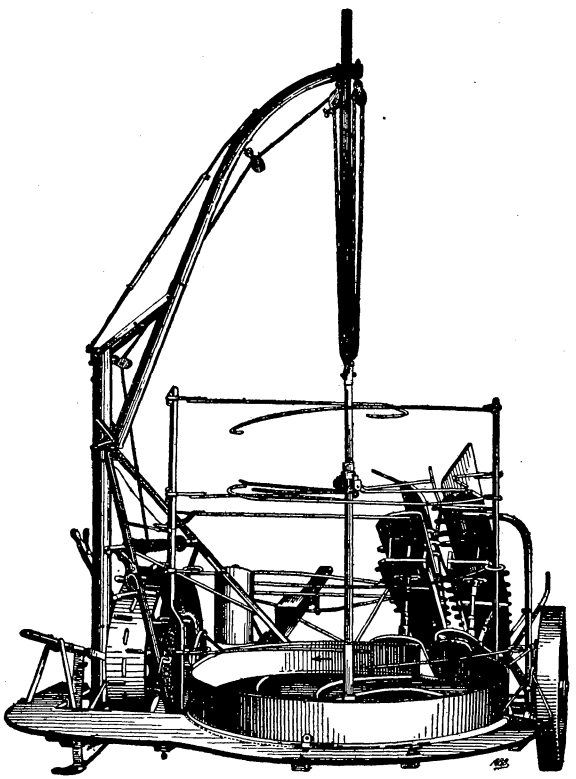

FIG. 16.—Corn harvester and shocker.

In 1893 a shocker was constructed by J. M. Shively, similar in principle but somewhat departing in its construction from the Hadley shocker in that the cutting apparatus and the dividers were like those of the corn harvester, and the retaining wall surrounding the shock-forming table was somewhat higher than that on the Hadley shocker.

The present form of shocker (fig. 16) consists essentially of the dividers already described in connection with the corn binder, a revolving table for assembling the shock, and a crane for removing it. The knives and fly-wheel attachment for cutting the stalks, and the arrangements for raising or lowering the dividers, and the frame are similar to those used on the corn binder. The table revolves in the

direction indicated by the arrow, and receives its motion from a bevel gear driven from the main drive and meshing into a rack on the outer edge of the table. As the machine advances the stalks are carried through the opening in the guard band. They are then caught by the spiral plates and the arms and forced around the central post. The arms also revolve, receiving their motion through the central pin from a gear located just beneath the table. Their motion is somewhat slower than that of the table. The guard or tension springs keep the stalks firmly compressed about the central post. Sometimes the twine is tied to one of the arms and allowed to assist in bringing the stalks toward the center by being wound about them as the arms revolve. This practice adds to the expense of operating the machine and does not materially improve the character of the work. At the outer edge are posts which support the tension-springs.

When the shock is fully assembled on the table it must be tied by hand. The shock may then be raised from the table by turning the crank, and winding the rope about a spool. The shock must be lifted high enough to clear the retaining wall. The tension springs are swung aside and the crank acting on a sector gear swings the shock free from the machine.

The arms (fig. 16), which are held in a horizontal position by the weight of the shock, are released the instant the rope is given slack. This release of the arms is brought about by a unique arrangement of a cam and pawls. When the rope is tight owing to the weight of the shock, the pawls are held in the grooves of the cam because the weight is carried from the pulley. When the rope is given slack the pawls are no longer kept from slipping out of the grooves in the cam, the shock moves through a small arc of a circle and drops to the ground, and the central supporting post is then raised to its position on the machine. The whole operation of forming, tying, and setting a shock can be done in five minutes. The shocks are somewhat smaller than those ordinarily made where corn is cut by hand or with a binder, averaging about 100 hills per shock, but the smaller size is necessary and makes it possible to reduce the weight of the machine. The smaller shocks also tend to cure more rapidly. The adjustment of the frame admits of the low cutting of the stalks. This results in a greater weight of fodder per acre and leaves a short stubble that readily turned under at the spring plowing.

Cost and efficiency.

Corn shockers cost about as much as corn binders and weigh approximately the same. The shocker has the advantage of requiring the work of but one man, whereas the binder requires, besides the driver, two or three men to follow and shock the corn.

The replies to inquiries indicate that the average number of acres of corn which can be cut per day with a corn shocker, three horses, and one man, is about 4.7 acres. The wear and tear is less than on a corn binder, and the life of the machine ought to be greater. Assuming that the allowance for first cost, life of machine, and interest on investment is the same as that for the corn binder—i. e., 29 cents per acre; allowing $3.55 per day for driver and team, or 75 cents per acre; and estimating that the twine required per acre cut with the shocker will not cost over 2 cents, we have a total cost of harvesting corn with a corn shocker of $1.06 per acre, as compared with $1.18 per acre for harvesting with a sled harvester, and $1.50 per acre with corn binders or by hand.

The shock made by the corn shocker is not so easily loaded on a wagon as is that made by a corn binder, as the individual bundles may be loaded with a pitchfork, whereas the whole shock made with a shocker can best be loaded at once, and this requires some form of loading device or horsepower derrick.

The corn binder is well adapted for cutting corn for the silo, as the bundles are bound into convenient size for handling, but this saving of labor is accomplished at the cost of twine. A corn shocker arranged to load the shocks on a wagon would no doubt prove the cheapest method of harvesting corn for the silo.

The general verdict of farmers who have used both the corn binder and the shocker is that the shocker is the preferable machine for harvesting corn.

A CORN-SHOCK LOADER.

A loading device for handling the shocks adds greatly to the value of the shocker, for with it the corn can be more cheaply handled than by the present methods. One of the first devices of this kind consisted of a long pole or pipe supported on a fulcrum at the rear end of the wagon in such a way as to give considerable leverage. The idea was much like that of the old well sweep with the semirotary motion added.

An improved loading device which can be carried along with the wagon or left in the field and driven about independently, is mounted on four wheels, and consists of an adjustable vertical mast on which is a horizontal steel cross arm. On this is mounted a traveling block fitted with pulleys through which a rope passes. To the end of this rope is hitched a horse which lifts the load. For loading corn shocks a grapple fork is used, which is slipped under the shock. The grapple arms are closed and with the pull of the horse the shock is lifted up on the wagon and laid on its side or stood on end, the grapple arms being released by simply turning the handle of the fork. This machine was originally designed to load corn shocks, and it

easily handles two shocks per minute, and will bear a stress of 2,000 pounds. It can also be applied to many other uses, such as loading hay, manure, small grain, dirt, lumber, telephone poles, and other heavy objects.

CORN PICKERS.

In the so-called "corn belt," where corn is the principal crop raised, it has not been possible so far to utilize all of the cornstalks. The crop is raised for the ears, which are picked by hand at maturity. To relieve farmers of this somewhat tedious work, for which it is often difficult to get sufficient labor, inventors have been busy for over fifty years trying to build and perfect a machine to pick the corn from the stalks.

DESCRIPTION.

A picking machine was invented by Quincy in 1850, and another by William Watson, of Chicago, shortly after. Practically all of the earlier corn pickers consisted of rollers inclining up in such a way that the front end of the rollers would pass below the lowermost ears and rake the stalk from the bottom to the top. A great many devices were employed for removing the ears, such as cutters, gathering prongs, rotating-toothed cylinders, roller and breaker devices, parallel vibrating bars, etc. The early machines were designed to be pushed from the rear and were provided with some form of dividers to guide the corn to the snapping devices, as shown in figure 17. The snapping-roller type of corn picker received serious attention from manufacturers about 1874, when the first machine of this type was invented, but it was ten years later that it was patented. The rollers were placed in the inclined position for the stalks of corn to pass between them. The end portions of the rollers where the stalks entered were provided with bars designed to aid in snapping off the ears as the stalks passed down between the rollers during the advance of the machine. For the remainder of their length the rollers were so constructed as to tear the husks from the ears and continuously feed the ears along, to be finally discharged, husked, onto a conveyor, and delivered into suitable receptacles. This particular machine was

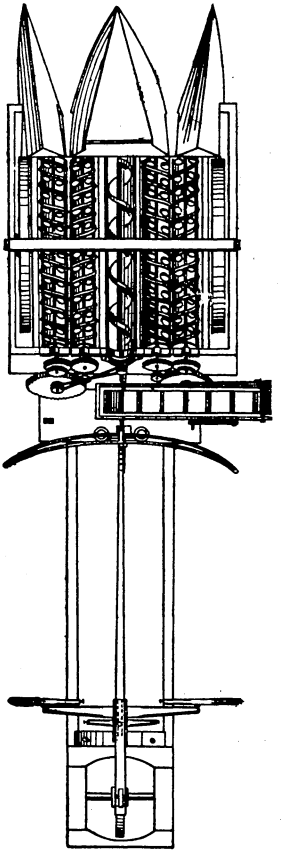

FIG. 17.—A corn-picking machine.

thought to promise success, but when the corn binders began to be developed and came into use the interest in corn pickers abated, as it was thought that with a successful corn binder there would be no need of corn pickers. However, the use of the corn binder and the shocker, while quite extensive, does not solve the corn-harvesting problem in the purely corn-raising regions, where a large share of the corn is still picked by hand from the stalks as they stand in the field.

About 1902 the attention of manufacturers was again turned to corn pickers, and several machines are now being introduced for picking corn. The corn picker as now constructed resembles the corn binder in the construction of the main frame, drive wheels, and dividers. It passes along the row of corn, which is straddled by the dividers, and the stalks, after being righted by the points, chains, and other devices, pass between a pair of inclined, corrugated rollers that snap or strip off the ears. The rollers are so placed that the ears fall naturally into a trough that extends along beside them. In order to provide snapping rollers to remove the ears and force them to fall always to the same side, yet permit free entrance of the upright stalks at the receiving end without the necessity of auxiliary means to bend the stalks laterally, James E. Goodhue arranged the snapping rollers in slightly skewed relation, by which the upright stalk may be gradually forced to one side as the picking rolls pass along, and the ears are broken off and directed to one side. The ears are carried back by a traveling conveyor and either delivered to a set of husking rolls or else, without being husked, carried by an elevator and delivered into a wagon which is driven alongside the machine.

Another form of modern practical corn picker has the guide chains with the usual prongs for straightening up the stalks. The chains form a stalk passage extending rearward through the machine. A rapidly moving chain provided with fingers is located at one side and between the guide chains in such a position that, as the machine passes over the row, the fingers engage the ears on the stalks and snap them off. By means of a deflector the ears are directed to a receptacle from which they are carried to the husking rollers and thence to the wagon. The tops of the cornstalks are cut off, and by means of a conveyor this and other trash is carried to the rear and dropped on the ground.

OBJECTIONS AND ADVANTAGES.

The corn picker is intended to remove the ears from the stalks, which are left in the field. Most of the machines are built on the assumption that the stalks are valueless, and therefore they are practically destroyed. It has not been possible to construct a picker

that will not to some extent break down or tear down the stalks. This is somewhat objectionable because, where the corn is picked by hand, the dried corn leaves and stalks serve as roughage for cattle during the fall and winter. The machine has, however, this advantage, that the field can be picked quicker and the cattle turned in earlier to make use of the roughage before the snow falls.

Another objectionable feature of the corn picker as compared with the hand method of picking corn is that it shells considerable corn; and, if the corn is lodged and tangled, more or less ears are missed by the machine. The corn picker with the husker attachment requires considerable motive power, at least four horses being required to pull it. For this reason some manufacturers have dispensed with the husking attachment and depend upon the snapping rollers for removing most of the husks. Machines of this kind will remove from 25 to 75 per cent of the husks, depending upon the stage of maturity of the corn, the brittleness of the stalks, and the effects of freezing and damp weather. Where machines without the husker attachment are used a stationary husker may be provided at the crib, in which the corn is husked and elevated into the corncrib.

There is a variance of opinion among the farmers as to the advisability of husking the ears clean. In the South the common practice is to leave the husks on the ears, and it is claimed that this practice tends to prevent injury by insects. In the North it is the common practice to husk the ears clean before they are cribbed. The objections offered, in reply to inquiries, to using a corn picker which leaves the husks on the ears are that more crib room is required for the ears; that they will serve to attract and harbor rats and mice; that the ears will not dry out, but will be liable to mold; that the husks interfere with the shelling; that, while for feeding cattle and hogs the husks will be advantageous, as they will serve as a roughage, horses will toss the ears in trying to remove the husks, and thus lose ear and all. For selling purposes the corn needs to be husked clean in order to command the best market price.

COST AND EFFICIENCY.

The corn picker should last about as long as the corn binder, or 8.17 years, and pick about the same number of acres per day as can be harvested with a corn binder, or 7.73 acres. The first cost of the machine is, however, practically twice that of the corn binder, or, on an average, $250. This makes the cost of machine, interest on the investment, and repairs equal to 58 cents per acre. The cost of driver and team is $3.55 per day, or 46 cents per acre. There is required two wagons with teams to remove the corn from the machine and deliver it into the crib, which, at $3 per day for each, costs $0.77 per

acre, or a total cost of $1.81 per acre for picking corn with a corn picker.

From 300 replies received to questions sent to numerous farmers in different parts of the country it was learned that the average yield of corn was 44 bushels per acre; that the average cost per bushel for picking corn by hand was 3½ cents, and that the average man picked 59 bushels of corn per day. This yield is considerably above the average given in the crop reports of the United States Department of Agriculture, but it represents the yield of corn in States where pickers are used. Considering, now, that the number of acres which the corn picker can cover per day is 7.73, this would, for the average yield, be 341 bushels of corn per day. It would require the time of 3.8 men to do the same work in the same time by hand as is done with the machine, at a cost of $11.93 for labor, but in addition to the wages of the men there is need of a team and wagon for every two men who pick corn by hand to haul the corn to the crib. These teams are worth at the very least $1 each per day, or three teams for the 7.73 acres would cost $3. The total cost for picking the same number of acres of corn by hand as can be picked with a corn picker, per day, would be $14.93, or $1.93 per acre, as compared with $1.81 per acre for machine picking. While the saving effected with the corn picker is not large, the use of a machine makes the farmer more independent of the labor market, as the work may be done without hiring extra men at a time when they are hard to secure. But the advantage of hand over machine picking in the removal of the husks should not be overlooked.

The corn picker is still an experimental machine, and not until it has been perfected should the farmer purchase it.

HUSKERS AND SHREDDERS.

SIMPLE HUSKING DEVICES.

One of the earliest devices used for husking corn was the husking peg. Several patterns of this are in common use. There are also other aids to corn husking made in the form of gloves, with projecting points or pegs. Equipped with such a glove the man husks the ears by tearing off the husks and snapping the stems.

EARLIER MECHANICAL HUSKERS.

The first patent on a corn husker was issued in 1837. The machine comprises essentially a pair of roughened parallel rollers designed to tear off the husks.

In 1866 a New York concern began the manufacture of a husker having a single snapping roll made of hardwood. Another roller set

with stiff knives located just behind the hardwood roller cut the stalk into short lengths. The ears of corn, as they were broken off by the snapping roll, fell down upon the husking rolls. These were about 2 inches in diameter and rotated toward each other. A small revolving shaft set with spikes and located directly above the line of contact of the husking rolls caused the ears to revolve so as to present all of the husks to the action of the husking machine.

Another form of husker consisted of a snapping roll much the same as that described above and several husking rolls whose effectiveness depended upon the action of rubber aprons. These passed over each roller like belts over a pulley and tended to draw the husks in with them. Later, about 1880, Phillips and Jones added to this idea by putting on a pair of snapping rolls. These were the first really successful huskers.

COMBINED HUSKERS AND SHREDDERS.

Thus far no machine had been produced designed to perform more than one operation on the stalks, except some of the unsuccessful and later experimental harvester types designed to pick and husk the

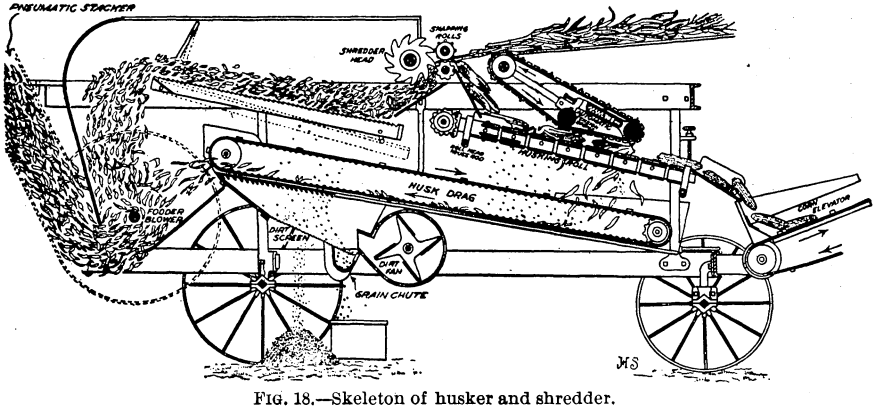

FIG. 18.—Skeleton of husker and shredder.

ears, as previously described. Between 1880 and 1890 a great deal of attention was given to thrashing corn. This practice so battered the stalk as to make every part of it available as a cattle food, putting it in more palatable form than the ordinary fodder cutters then in use. The repeated shortages and failures of the hay crop during the decade 1880–1890, together with the results of attempts at thrashing corn, led to the invention of the combined husker and shredder, which takes the stalks with the ears on them, removes the ears, husks them, and prepares the stalks for feeding. A combined husker and shredder patented by J. F. Hurd, of Minnesota, in 1890, application having been filed in 1887, is one of the earliest of the shredder type.

There are at this time many different makes of this machine in the market. They are of various designs and are frequently made so as to be fitted with exchangeable cutter and shredder heads. The general construction of all machines of this class is very much the same, however. Some are rather complicated in their construction, while others are very elementary. By referring to figure 18 the construction will be easily understood.

The stalks are first fed to the snapping rolls, where the ears are broken from them. The stalks are driven forward by the snapping rolls until they meet the shredder head, where they are cut to shreds by knives of special forms shown in figure 19. The shredded parts of the stalk fall upon a vibrating carrier whose motion is comple-

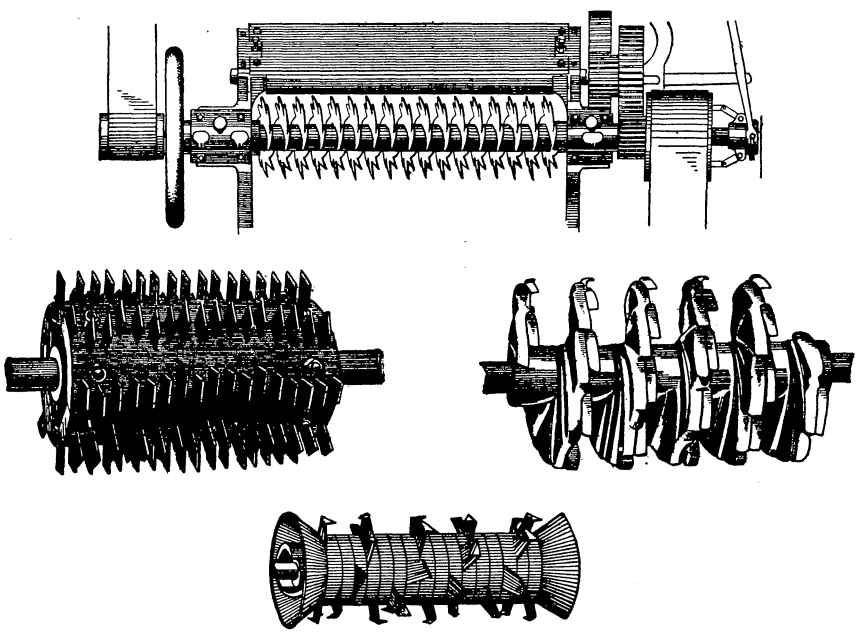

FIG. 19.—Forms of shredder heads.

mented by the action of arms. The shreds fall from this carrier into the blast from the fodder blower, which carries them up through the stacker.

The ears which are broken from the stalks by the snapping rolls drop upon the husking rolls, where the husks are torn from them. The husked ears gradually descend along the inclined husking rolls until they finally fall upon an elevator which carries them to the bin or other place provided for them.

The husks fall upon a conveyor chain which drags them back to the fodder blower, where they join the shreds from the stalk. The loose grain falls from the vibrating carrier and husk conveyor upon a screen. As it falls it is met by a mild blast, which removes the dust from it.

This grain is then collected in a trough or chute and is driven by means of a screw conveyor to one side of the machine.

This machine combines in its construction many elements used in earlier machines, both huskers and fodder cutters. The snapping rolls and husking pegs are both ideas found in machines described in preceding paragraphs, while the shredder heads are not greatly different from those of the fodder cutters of earlier design. The blower and cleaning and carrying devices are very much like those of the thrasher. Self-feeding and safety devices are now largely used as a protection against the danger of having one's hand or arm caught in the mechanism (fig. 20). Where the self-feeder is used, a revolving band cutter is commonly placed a little ahead of the snapping rolls.

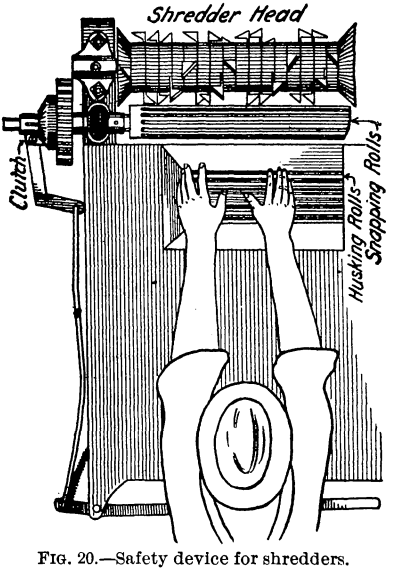

FIG. 20.—Safety device for shredders.

The superior convenience of having the stalks bound into bundles is most evident where these machines are used. In bundles the stalks keep straight and thus avoid the delay caused by having them come to the machine in a disordered condition. There is also less danger of choking the machine.

ECONOMY OF CORN-HARVESTING MACHINERY.

HARVESTING WITH THE BINDER.

We have found that the average life of the corn binder is 8.17 years and the cost $125. If a man has only 20 acres of corn to cut per year the cost for the use of the binder for each year would be $15.30. To this should be added $7.20 for interest, making the total annual cost of the machine $22.50. Other expenses for cutting the 20 acres of corn, according to the previous averages derived, would be $9.20 for team and driver, $6.10 for twine, and $8.96 for shockers; or a total cost for cutting 20 acres of corn with a corn binder of $46.76, or $2.34 per acre. We have seen that the work may be done by hand for $1.50 per acre and that by hiring a neighbor's team and binder at 75 cents per acre the work may also be done for $1.50 per acre. We may then conclude that a farmer who has only 20 acres of corn to cut per year, and does not intend to cut any for his neighbors, would lose money by purchasing a corn binder.

If a farmer has 30 acres of corn to cut per year the annual cost of the machine, including interest, would be 75 cents per acre. It will require a cut of at least 80 acres per year before the farmer can properly estimate the cost per acre for the use of the machine to be 29 cents, as already given. It may, therefore, be concluded as a general proposition that unless this number of acres is available for cutting each year the investment in a corn binder is not profitable.

These estimates may not be exactly fair, because if the corn binder cuts but 20 acres per year the life of the machine with proper care would probably be considerably longer than eight years. There is no doubt that in general half the money spent for implements could be saved if they were given better care when in use and when not in use protected in an implement shed from wind, rain, sunshine, and farm animals. In general it is better not to invest in expensive implements unless there is sufficient work in sight to make them profitable.

PREPARING CORN FODDER.

The cost of preparing corn fodder by the various methods and with the different machines depends upon a great many variable factors. It depends upon the yield of corn per acre; upon the method of harvesting; upon the distance the fodder is to be hauled, the size and efficiency of the working force, the size, capacity, and speed of the machine, and the motive power used.[a]

We have already learned the cost of cutting the corn and putting it into shocks, and also that the average cost per bushel of husking corn from the shock in the fields is 5.3 cents per bushel, or at an average of 44 bushels per acre the cost will be $2.33 per acre. To this should be added about 35 cents per acre for hauling the ears to the crib, or a total of $2.68 per acre for husking the corn by hand, and this leaves the stover in the field. If the stalks are hauled to the feed lot it will involve an additional cost. When huskers and shredders are used for husking the corn and shredding the fodder the farmer will have to decide the question as to what method of doing the work he desires to employ. There are machines on the market which will husk but 100 bushels per day and there are those which will husk 1,000 bushels per day. The smaller ones are for the farmer who desires to do his own work.

With the general introduction of the gasoline engine on the farm a small individual outfit is very desirable. With such an outfit the farmer may do his work at his convenience, as he needs the corn and the fodder, and may also do some work for neighbors, which will aid in paying for the machine. It requires one man to feed; one to look

[a] The question of methods and cost of preparing silage from corn is discussed in U. S. Dept. Agr., Farmers' Buls. 32 and 292, and need not be further considered here.

after the engine, shredder, and the corn in the wagon; one man in the mow to remove the fodder, one to unload the wagons, two teams, and one loader in the field. Six gallons of gasoline will supply the fuel for a ten-hour run. The computed cost would be:

Cost of shredding corn.

Use of engine and shredder and repairs, per day	$1.00
Five men, at $1.50 each	7.50
Two teams, at $3 each	6.00
Power, 6 gallons of gasoline, at 15 cents per gallon	.90
Total cost per day	15.40

From experiments conducted by the author with the above outfit it was found that the number of bushels husked per hour varied considerably with conditions, but that the average was 18 bushels, or 180 bushels per day. This, at the average yield of corn per acre previously derived, would be equal to 4 acres per day. To husk 180 bushels by hand and put it in the crib would cost $10.96. This would leave a cost of $4.44 for 4 acres of corn fodder shredded and delivered in the mow. The average yield of shredded fodder is 2 tons per acre. This would give a cost of 55 cents per ton for hauling the fodder from the field, shredding it, and placing it in the barn ready to feed. When corn has been husked in the field and the farmer wishes the fodder shredded it costs him about $1.50 per acre for shredding the fodder by machine.

With large machines the work of husking and shredding corn is usually custom work. The owner of the machine furnishes the shredder and engine, with two men, charging the farmer from 4 to 5 cents per bushel for this work. The farmer will have to furnish the fuel and the teams, as well as the balance of the help, to run the machine. These large machines require from 6 to 8 teams and 20 to 25 men for full operation. The large machine, while it does the work quickly, has the disadvantage of requiring a large crew of men and teams and if anything goes wrong with either engine or shredder this force is idle at the expense of the farmer until the machine is repaired.

From some investigations conducted by sending out letters of inquiry from the Iowa Experiment Station to all parts of the State, the following results were obtained:

From the entire number of reports received the average cost of machines for shredding was $1.55 per acre; the cost of fuel was 31.4 cents; and the total cost of shredding, per acre, varied from $2.45 to $6.65. This is a wide range, but the conditions under which the shredding was done varied correspondingly according to the distance hauled, yield of stover per acre, kind and size of machine used, and work required in moving the outfit; also as to physical conditions of the fodder and accidents with machine.

The average cost of shredding 1,600 acres was found to be $4.41 per acre, and this is believed to be a fair average under ordinary conditions.

The estimate of yield of corn per acre in the above case was 57.25 bushels, which is rather high, even for Iowa; the yield of fodder 2 tons per acre, and the cost of husking in the field 5 cents per bushel. At these figures the cost of shredding the fodder would be 77 cents per ton.

SUMMARY.

Summarizing the comparative returns per acre of husking corn from the field, of cutting and feeding from shock, and of cutting and shredding by the various methods, it is found that the net value of the crop is $17.93 for husking by hand and leaving the stalks standing in the field. This is obtained by adding to the net value of the corn 55 cents per acre for the stalks and subtracting the cost of husking by hand.

By allowing 25 cents per acre as the value of the fodder in field where a corn picker is used, and adding this to the net value of the corn and subtracting $1.80 per acre for picking with the machine, we derive the net value of the crop of $17.81 for this method of harvesting, which indicates a small loss per acre as a result of using the corn picker.

The net value of the crop by feeding the stalks whole ($23.18 for hand husking, $23.50 for harvesting with large machines, and $23.62 for small machines) is obtained by taking the total value of the corn and fodder and subtracting the costs of cutting and husking by hand, cutting with sled harvester and husking by hand, and cutting with corn shocker and husking by hand.

The net value of the crop by utilizing the fodder in the shredded form ($24.68 for hand harvesting, $25.45 for harvesting with large machines, and $26.45 with small machines) is obtained by assuming a greater value of shredded fodder over whole cornstalks of 33 per cent, adding this value of the fodder to the value of the corn and subtracting the various costs of cutting, husking, and shredding the corn by the various hand and machine methods.

CONCLUSIONS.

The farmer who would secure the full value of his corn crop should secure the fodder with as much care as he gives his clover hay, harvesting it at the proper period, and not allowing it to become ruined by rain or frost. By the use of the proper machinery for harvesting the corn crop, the farmer may considerably increase the net income from his crop over hand methods of harvesting the ears and wasting the stalks and still allow full price for the use of the different machines.

There is a limit beyond which it is not profitable for a farmer to invest in corn-harvesting machinery, and the amount of work to be done by the machine each year should be carefully considered before a purchase is made.

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